

Unmanned Aircraft: A Pilot's Perspective

"It's not un-piloted..."



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Note: The information in this presentation is the author's and may not reflect official NASA policy

TOPICS

- **Pilot – Vehicle Interface Design**



- **Concept of Pilot / Operator**



- **Western States
Fire Mission**

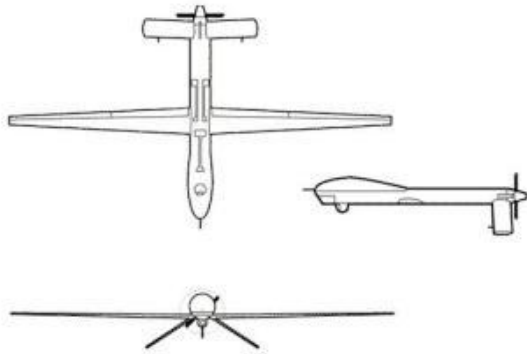


A LEGACY OF UAV RESEARCH at NASA DRYDEN

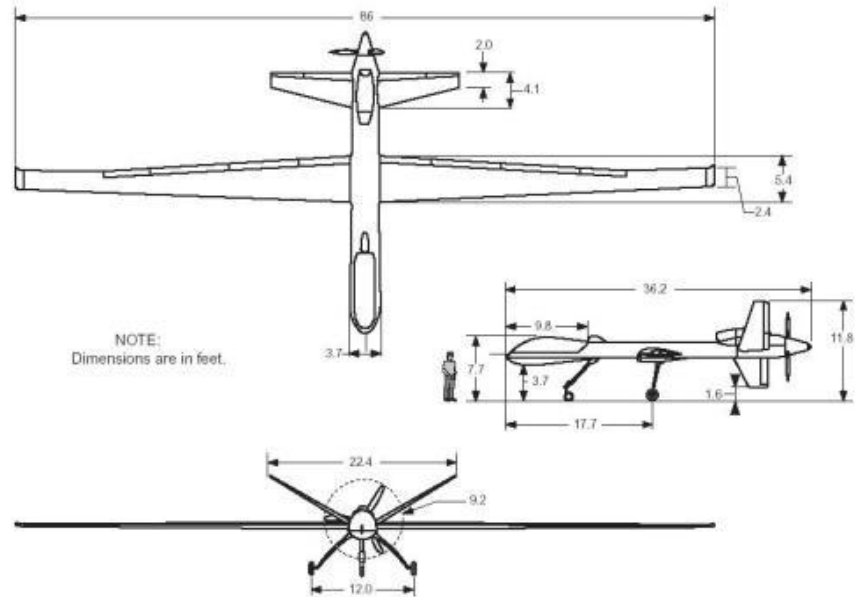


More Uninhabited Vehicles





MQ-1 Predator -A



MQ-9 Reaper/ Predator-B



NASA *Ikhana* UAS

General Atomics, Aeronautical Systems Inc.

MQ-9 “Reaper” (Predator-B)

***Ikhana* = Native American Choctaw word for
“Intelligence”, “Learning”, “Awareness”.**



 **GENERAL ATOMICS**
AERONAUTICAL SYSTEMS

Initial power-up,
fueling, engine start,
and local area flying

**C-Band
Line-of-sight
antennas**



Ground Control Station



Over The Horizon
Long Range Link
Ku-bandSatCom



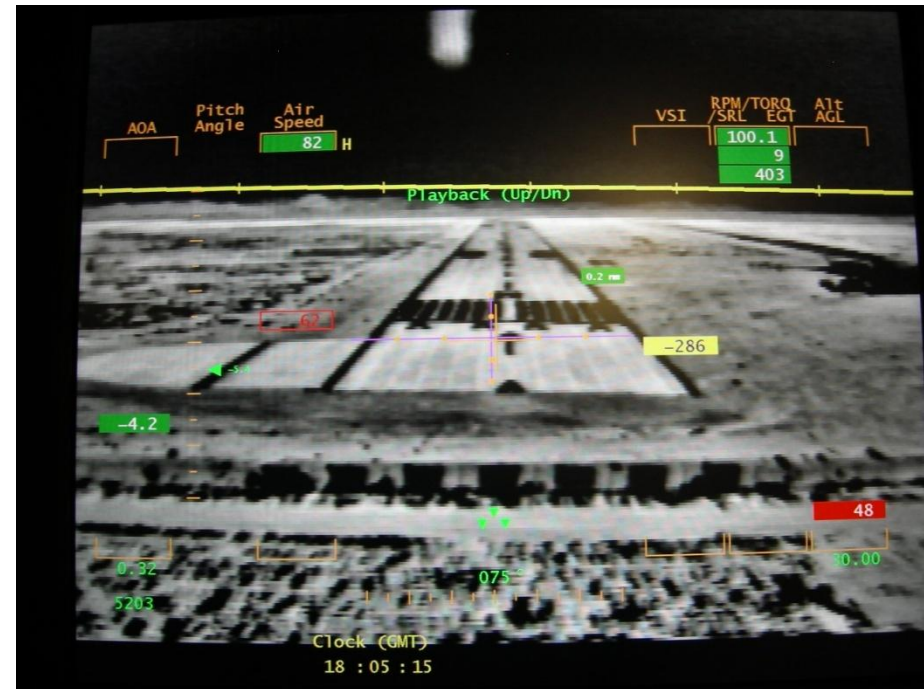
MQ-9 Ground Control Station (GCS)



Two Pilot Stations









So, what's it like to fly a UAS?

Well....What if you stepped into your cockpit...

...and you lost 4 of your 5 senses?

You only have *vision*!



Only 1 sense?

- You **can't hear** the engine rpm fluctuating
- You **can't feel** vibrations, accelerations or motion
- You **can't smell** the fuel leak
- You **can't taste** the electrical fire smoke
- AND, you **lose vision** in one eye, 30° FOV!
- WELCOME to UAS flying!

Pilot-Vehicle Interfaces

Displays and controls

- Post WW II: analyses of many accidents pointed to poor human-machine interfaces.
- Concerted effort over several decades has established standards and best practices for cockpit design.
- Multi-function, high task environment demands that error paths be minimized/simplified.
- Humans are tactile, visual, and analog...NOT digital.
- For the most part, the UAV development community has not utilized standardization of proven interface design.
- Some UAV mishaps are attributed to this (root cause).

The nightmare of poor interface design



With decades of evolving cockpit design, today's aircraft exhibit common standard control and display formats and arrangements.

Example: The “T” arrangement
It works in many types, small and large.



Cessna 182



Boeing 737

Humans are analog, tactile, visual.

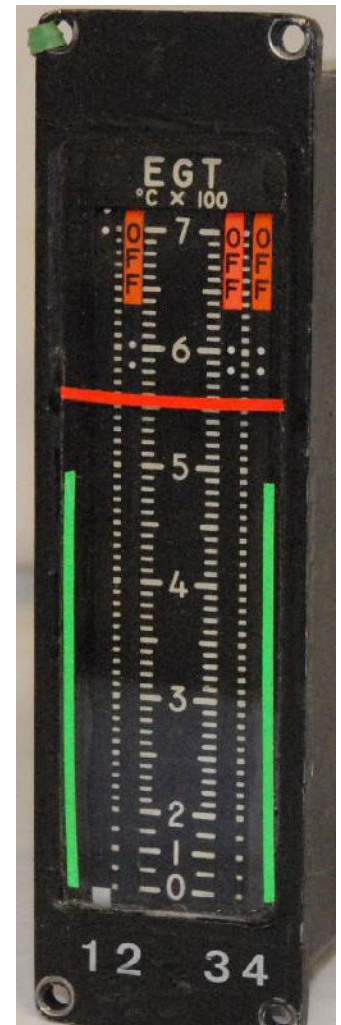
What about the displays and controls?



No need to memorize numbers if the normal range and limits are displayed (red lines, green arc).



Digital display might not readily show trends and relationship to limits



Digital Information Can be displayed in Analog Format



Unmanned Aircraft System
Digital /Tabular Display Format

Example of Display and Control Issues

IFF Transponder “IDENT” Task

1. Remove right from control stick
2. Move cursor to tracker display
3. Click on TOOLS menu
4. Scroll to IFF
5. Click to open IFF window
6. Click “IDENT” button
7. Click “APPLY”

Accessed by trackball
and Left/Right buttons

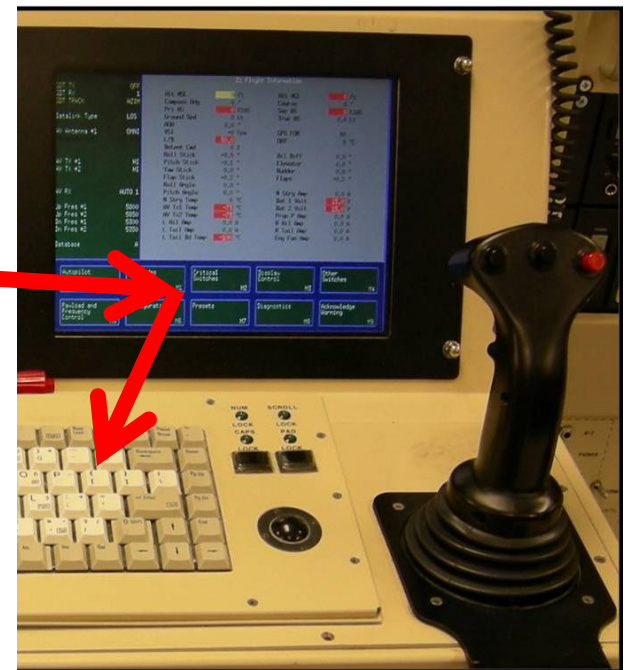


Example of control / display issues

Q: How do I TURN **ON**
the Fuel Heaters?

Fuel Heat Inhibit

Disable / Enable

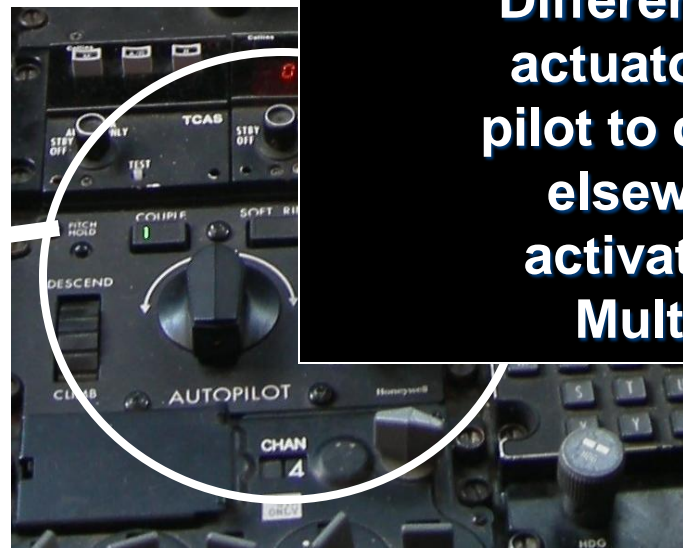




**Use of the
Tactile sense**



**Different shapes of
actuators enable the
pilot to direct attention
elsewhere...while
activating systems.
Multi-tasking**



RQ-4 Global Hawk

Length: 44 ft
Wing: 116 ft.
GWT: 30,000 lb

Altitude: 65,000 ft.
Endurance: 30 hours



Global Hawk Operations Center (GHOC)



NASA Global Hawk “cockpit”



Q: What's a "pilot"?



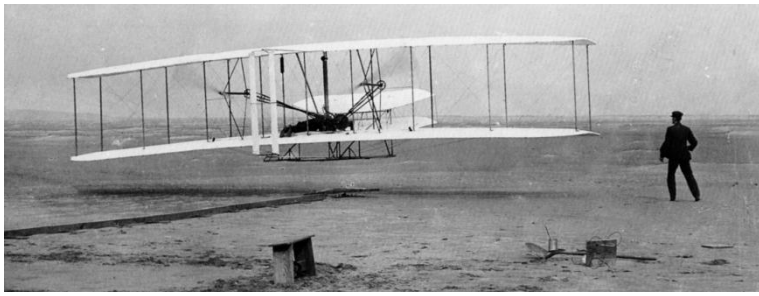


Samuel Clemens and his Pilot's Certificate

19th Century Pilot.

- Riverboat Captain
- Skills: River navigation, rudder control, soundings, shovel coal, supervisor...





20th Century Pilot

- Strapped to an airplane, direct interface to controls.
- Motor skills are primary metric of performance
- Increasing use of automation, systems management.





21st century pilot... "fly-by-wire"....

- "Remotely" connected to the controls, systems management, monitor autonomous operations.

- In some cases, motor skills have little/no relevance.

**Global Hawk cockpit:
Autonomous operations.
Mouse and keyboard controls.**



What is a “pilot” ?

Knowledge, Ability, and Skill Sets

(relative relationships are not necessarily to scale)



Video Gamer

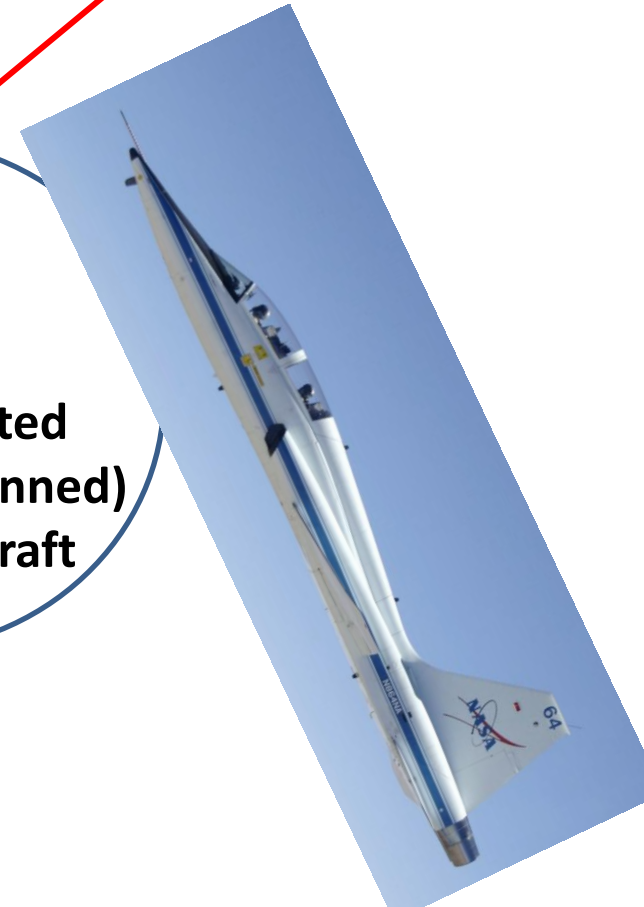


Radio Controlled
Visual Line-of-sight

Remotely
Piloted
Unmanned
Aircraft
System

Piloted
(manned)
Aircraft

What do these people
have in common?



What is a “pilot” ?

Knowledge, Ability, and Skill Sets

(relative relationships are not necessarily to scale)

Video Gamer

Reset Button

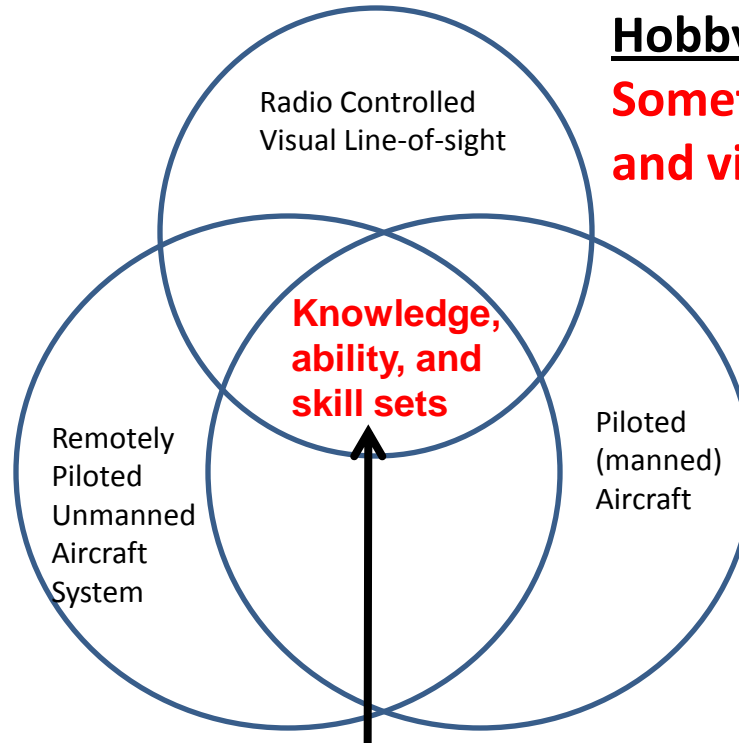
Model airplane

Hobbyist

**Sometimes...left is right,
and vice versa.**

UAV Pilot

**Skill sets depend on
control method**



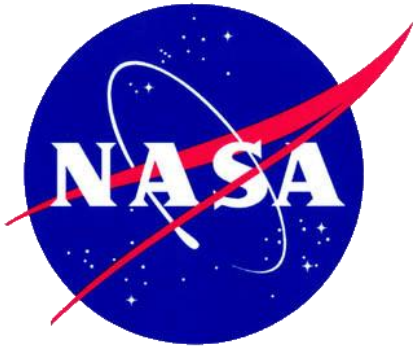
Jet Jock

Self-preservation instincts.

Airmanship / Air Sense / Knowledge: Navigation; Communication protocols; FAA Airspace Rules, Requirements, and Regulations; Terminal area procedures, Weather forecasting and alternate airfield assessment, Mission planning, Emergency procedures, aircraft systems, principles of flight, etc.

Considerations

- Classification of UAS Types = Operating Scenarios:
 - Radio Controlled Visual Line-of-sight
 - Remotely Piloted (motor skills)
 - Autonomous (**still requires “airmanship skills”**)
- Definition of “Pilot”
 - Training and qualification requirements derived from operating scenario
- Standardization of human-machine interfaces
 - Include the Air Traffic Controller



Western States Fire Mission





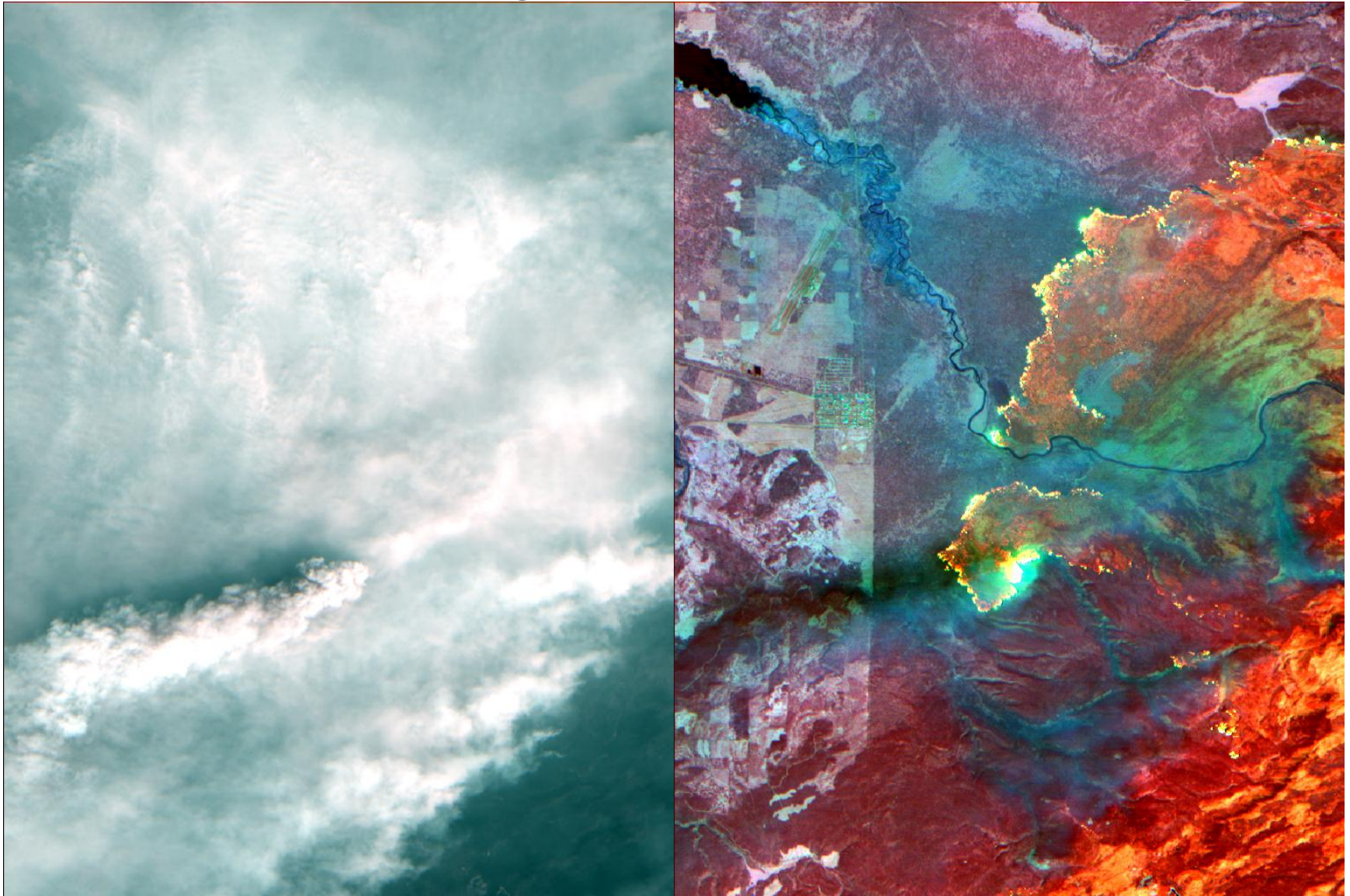
Where do you put
Limited Resources?



...and keep them
Safe!



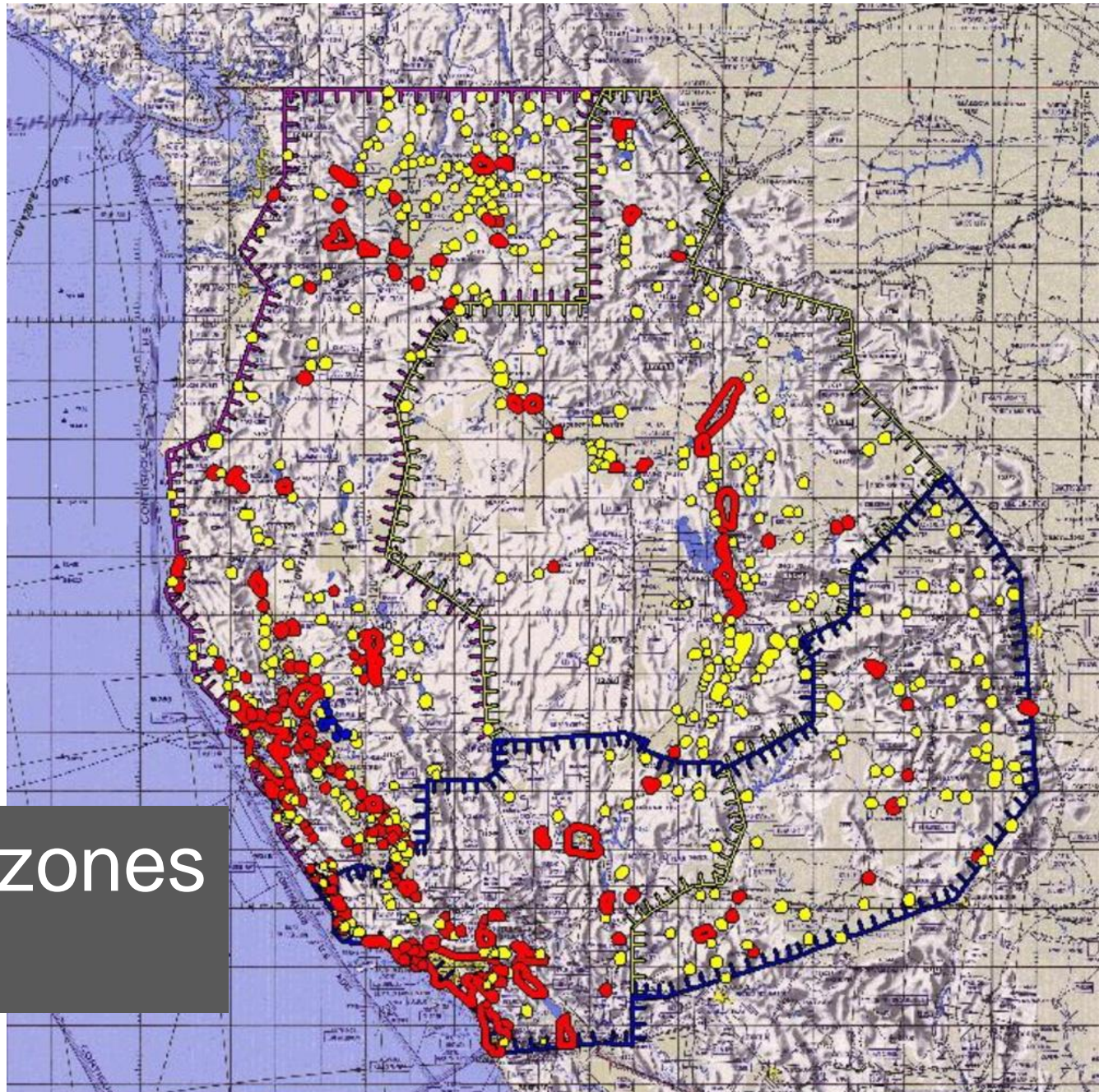
Visible Light...vs...Infrared Image



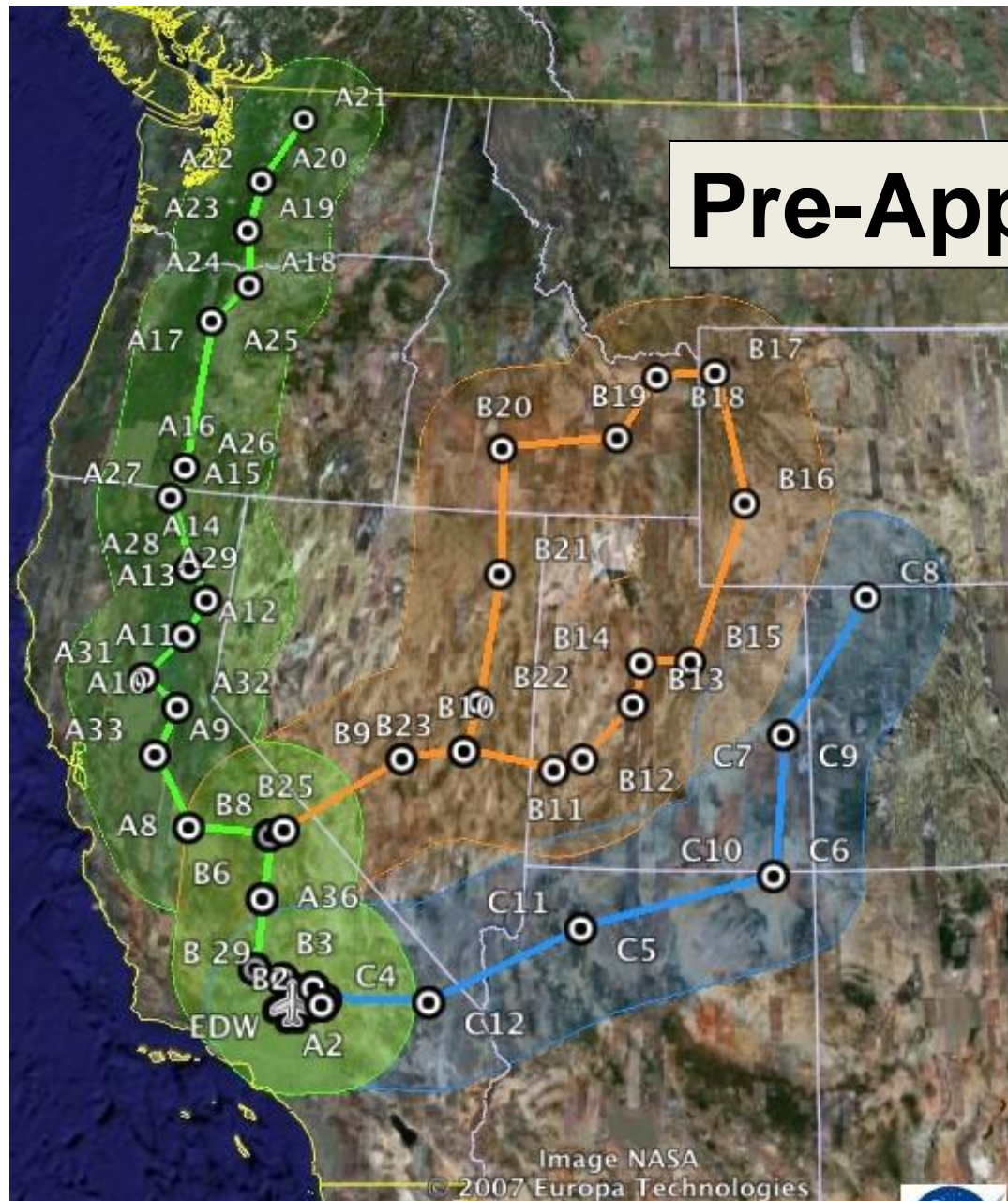
Challenges and Requirements

- Integration of the systems: airplane-sensor-data delivery
- End-to-end testing
- Satisfy customer requirements: timely geo-location of fire lines and hot spots
- Satisfy FAA provisions and restrictions...the COA
 - Only 3 routes, with deviations <75 nm
 - File flight plan 3 days in advance of flight
 - No emergency landings at public airports
 - One altitude (FL 230), no climbs/descents
 - “see and avoid” capabilities?
 - No flight in to forecasted “moderate or severe” turbulence
 - No flight in area where convective SIGMET has been issued
 - No flight in area of know or forecast icing
 - Lost link procedure: continue on route for 15nm, right turn, return home.
 - No flight in area affected by GPS testing

Keep-out zones



Pre-Approved Routes



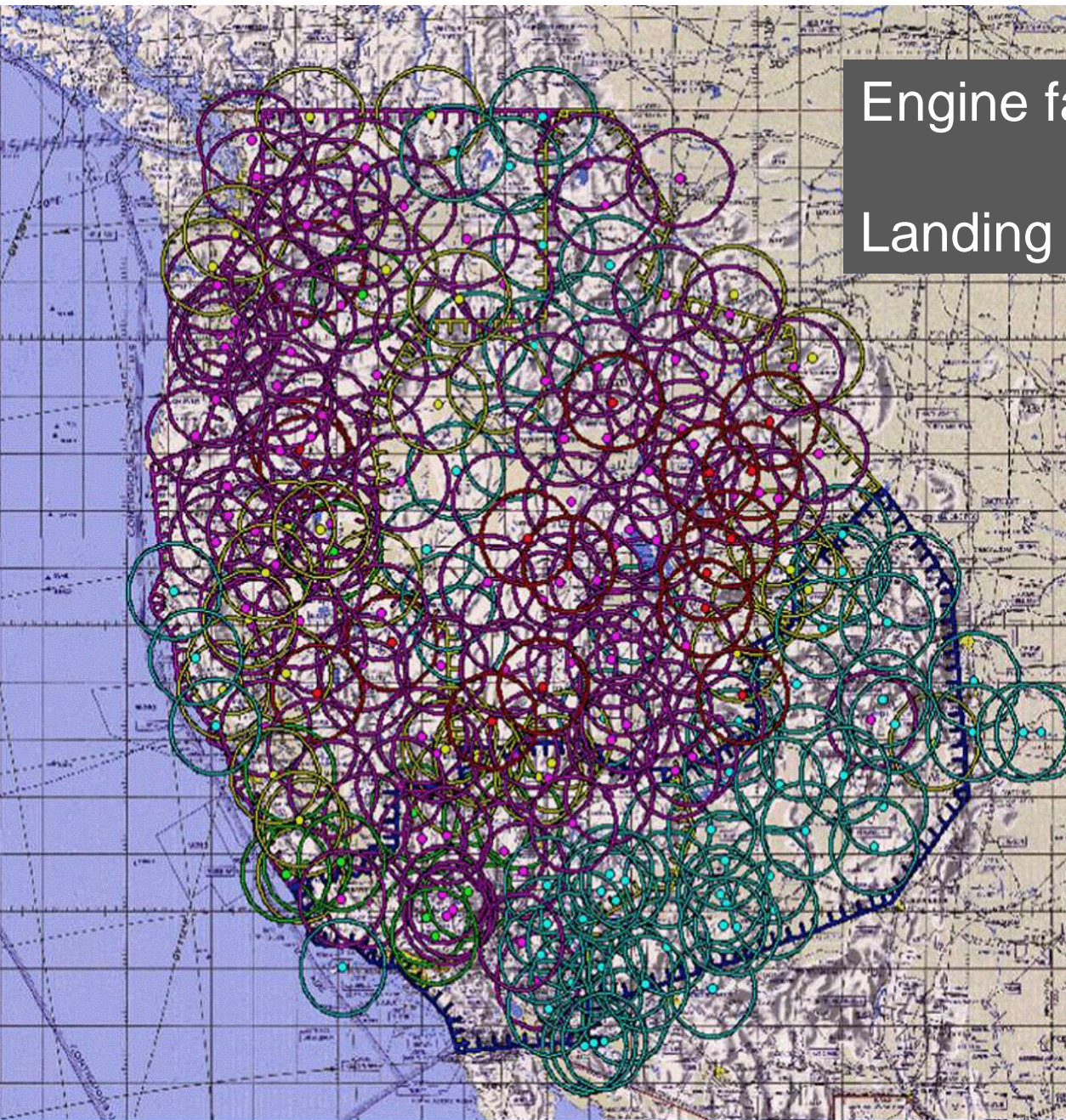
Actual flight route
negotiated in real-time
to acquire data over
fires.

Approved landing sites for
a generator failure and
range limited by battery
life.



Engine failure glide range

Landing sites



Four Tech Demonstration Missions

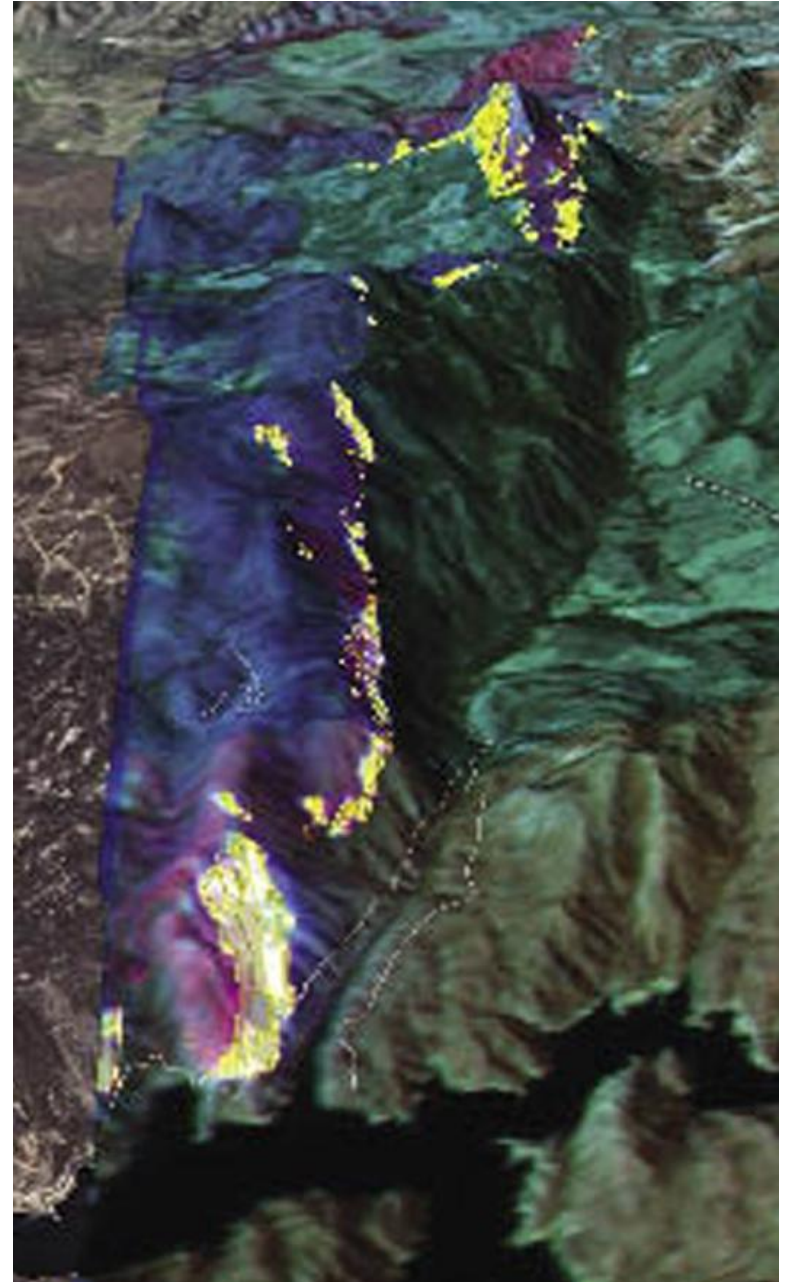




The end product:

Infrared data “draped” on Google Earth 3-D terrain maps.

Delivered to the Fire Incident Commander in less that 10 minutes.



Infrared Data and GPS locations are merged with
3-D Google Earth map/image

Ikhana-located
Hot spots

Known Fire line

Zaca Fire
Santa Barbara, 2007

© 2007 Google™

Successful Results

Quotes from the Fire Incident Commanders:

- “10,000 residences saved today, thanks to NASA...”
- “...fire-fighting resources effectively applied...”
- “I’ve seen the future, and it’s here.”

Considerations

- **Cockpit design: Learn from history**
- **Define “Pilot”. MORE than a systems operator.**
- **Optimize Situational Awareness**
- **Include the Air Traffic Controller in system interface design...it’s a total system.**
- **Minimize pathways to errors...and mishaps**
- **Reduce Risk...Increase Safety**

Thanks for listening.

